

Source Parameter Study of Hydraulic Fracturing induced Microearthquakes using Empirical Green's functions

Ahyi KIM^{1*}, IIDA, Shuhei¹, RUTLEDGE, James²

¹Yokohama City University, ²Schlumberger

Hydraulic fracturing is a technique used to allow economic production of gas and oil from low-permeability reservoirs. The technique is also used to enhance geothermal energy development. Currently, microseismicity induced by the fluid injection is routinely monitored to map the fracture growth process in real-time. A natural development is to characterize the mechanism of the microearthquakes. Understanding source characteristics of these events is expected to provide a better understanding of the fracturing process and the influence of pre-existing structures controlling the distribution of events. Although several focal mechanism studies have been done in gas and geothermal field, its estimation is often biased due to various errors. Often the most significant difficulty in retrieving the source parameters in these monitoring studies is from poor azimuthal coverage. To avoid these uncertainties in this study, we estimate the source parameters using the empirical Green's function (eGf) analysis. The eGf approach is advantageous because it can be performed with one receiver, and requires no assumption of geologic model. We deconvolve the smaller event from the larger events recorded at the same receiver to obtain the source time functions of the larger events. We use the source-time functions to fit the seismic moment and corner frequency of the source-time spectra using a least-squares curve fit to the f_2 spectra. The data we use were recorded during a hydraulic fracture imaging test in the Carthage Cotton Valley gas field of east Texas using two multi-level, three-component geophone arrays deployed in nearby monitoring wells. The treatments monitored include gel-proppant treatments using high viscosity fluids and low-viscosity water frac treatments. In this study we apply the eGf method to the events precisely relocated from two injection stages ($-2.4 < M_w < -0.6$). Preliminary result indicates source spectra of most events agree well with double couple event. We also examine the correlation of the corner frequency and seismic moment to investigate whether those events follows the self-similarity observed in tectonic events.

Keywords: Hydraulic fracturing, Microearthquakes, Empirical Green's function, Source spectra, Source characteristics, Scaling Law